MI-0296

Emittance measurement and acceleration – Revision of MI-0294

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Abstract

LLRF timing jitter was eliminated and the emittance was measured again to confirm that there is no undesirable emittance blow up. Beam acceleration to 120GeV has been done with low intensity beam.

1. Introduction

Previous beam studies have reported that there is an emittance growth when two bunch trains are recaptured[1]. Simulation studies have indicated that the emittance growth is caused by LLRF timing jitter. During a shutdown (Jan.13 03 ~ Feb.03 03), the LLRF jitter was eliminated and the emittance was masured again after the shutdown.

After slip stacking, the beam was accelerated to 120GeV.

2. LLRF jitters

Previously, LLRF did not have an adequate time resolution. Frequency functions(Fig.1) applied to the beam are calculated assuming that, at the time of recapture, two bunch trains are sitting exactly on the same longitudinal location, that is, two cavities are in phase. However, LLRF samples those functions at a rate of 720Hz and this does not give a needed time resolution to re-construct the rf frequency functions. As a consequence, the voltage after the recapture is not at its maximum value. Moreover, there was a jitter in the sampling so that the voltage after the recapture changed from pulse to pulse(Fig.2). The LLRF group has improved the system and now the time resolution of frequency curve is 10μsec/sample. With this improvement, the voltage after recapture was constant as shown in Fig.3.

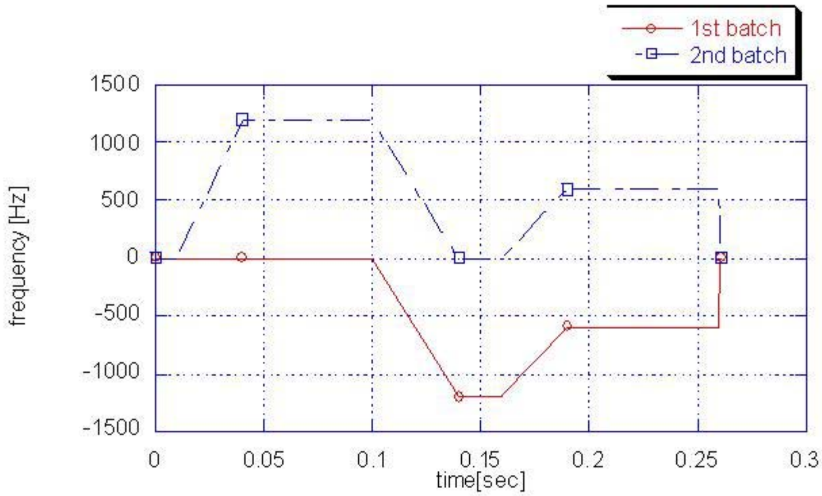


Figure 1. Frequency curves for the 1st bunch train and the 2nd bunch train as a function of time.

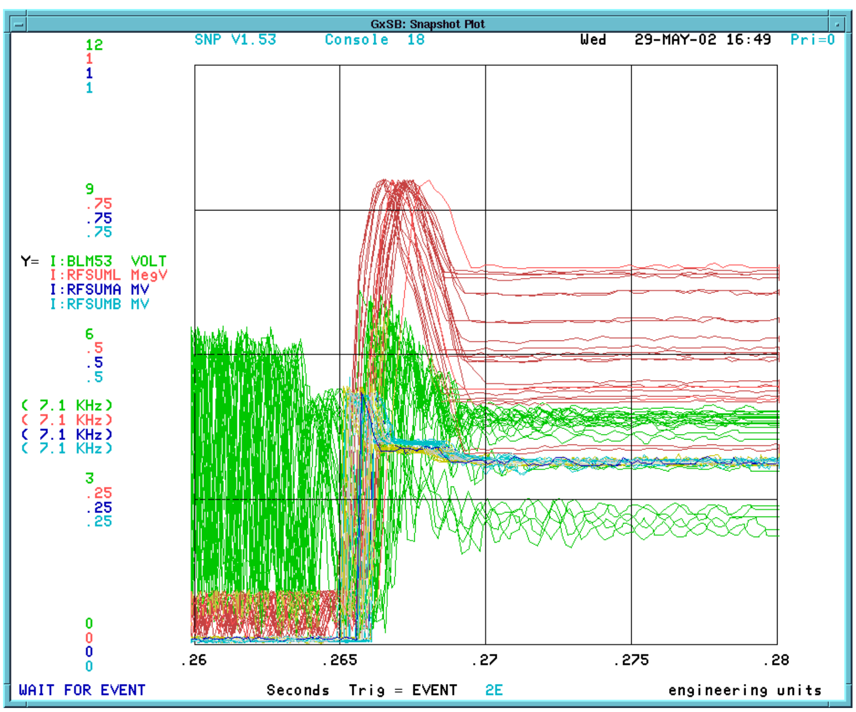


Figure 2. RF voltage(I:RFSUML) around the recapture time before LLRF timing jitter was fixed.

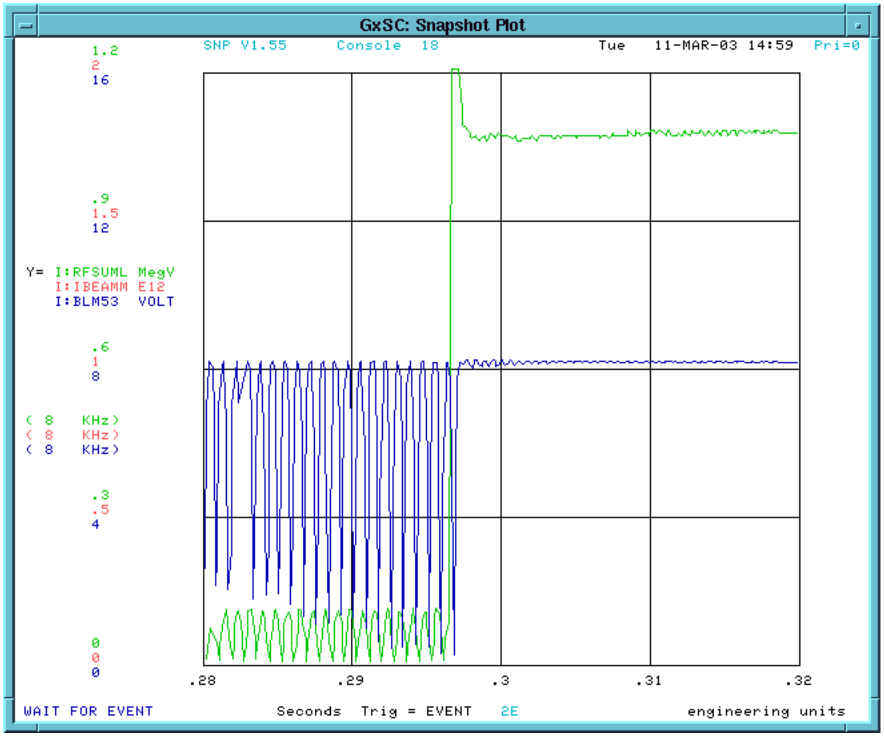
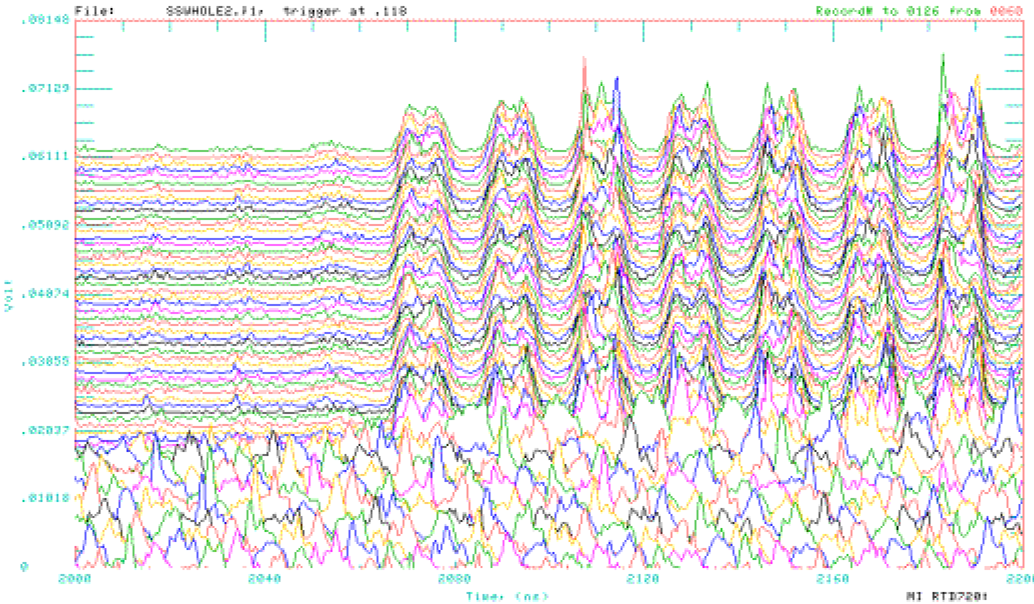


Figure 3. RF voltage(I:RFSUML) around the recapture time after LLRF timing jitter was fixed.

3. Emittance measurements

Figure 4, a mountain range picture, shows the progress of slip stacking around recapture time. The signal comes from a wall current monitor (WCM) with a resolution of 0.5nsec/sample. Upper picture was taken with LLRF jitter and lower picture after the improvement. The bunch width is now narrower than before.

The 95 % longitudinal emittance was measured again during 0.18sec and this was compiared with the previous one and plotted in Fig.5. A factor of 3.2 in the observed emittance growth rate is the same as simulation results and there is no unexpected emittance growth during slip stacking.



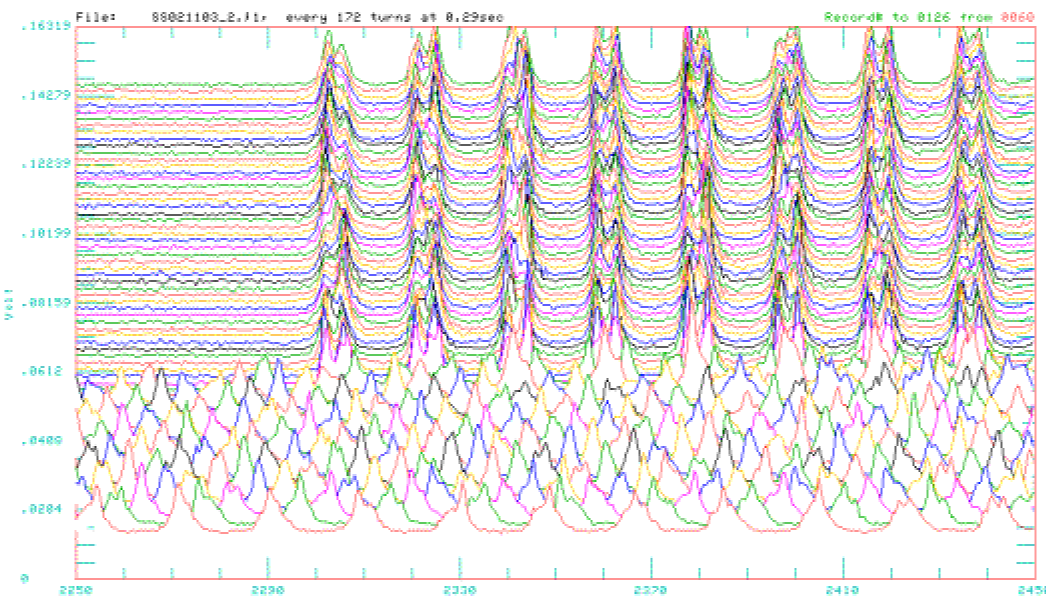


Figure 4. Mountain range plots of wall current monitor signals around recapture time. Upper: before the shutdown. Lower: after the shutdown.

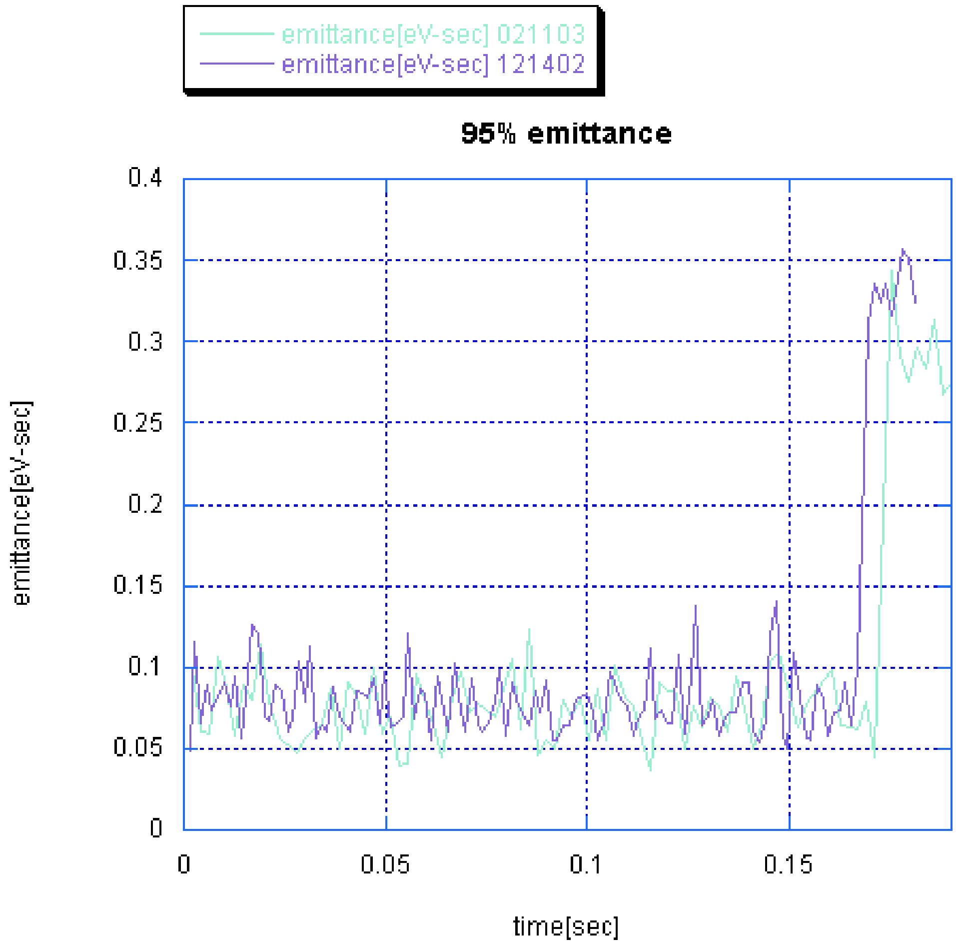


Figure 5. Comparison of the emittance before and after the shutdown. Blue trace: before the shutdown. Green trace: after the shutdown.

4. Acceleration

Acceleration was also tried. Figure 6 shows the beam intensity during beam acceleration. Approximately 1.0E12 total particles were injected, slip stacked and accelerated to 120GeV. There was a beam loss of ~2% at the beginning of acceleration.

The emittance at 120GeV was measured and plotted in Fig. 7. The observed value of 0.24eV-sec is less than that the one we currently have in the normal operation cycle.

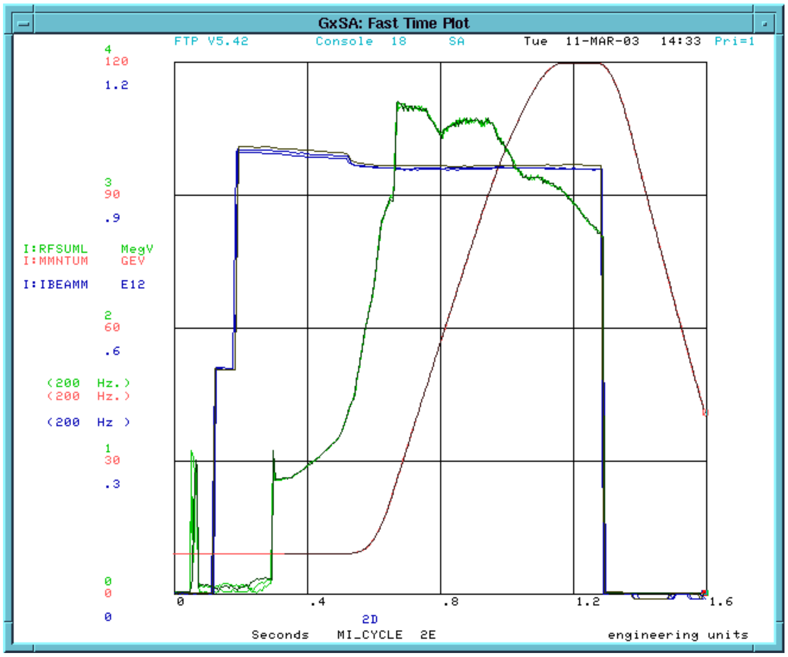


Figure 6. RFSUML: rf voltage[MV], MMNTUM: momentum[GeV], IBEMM: total beam intensity [E12 ppp]

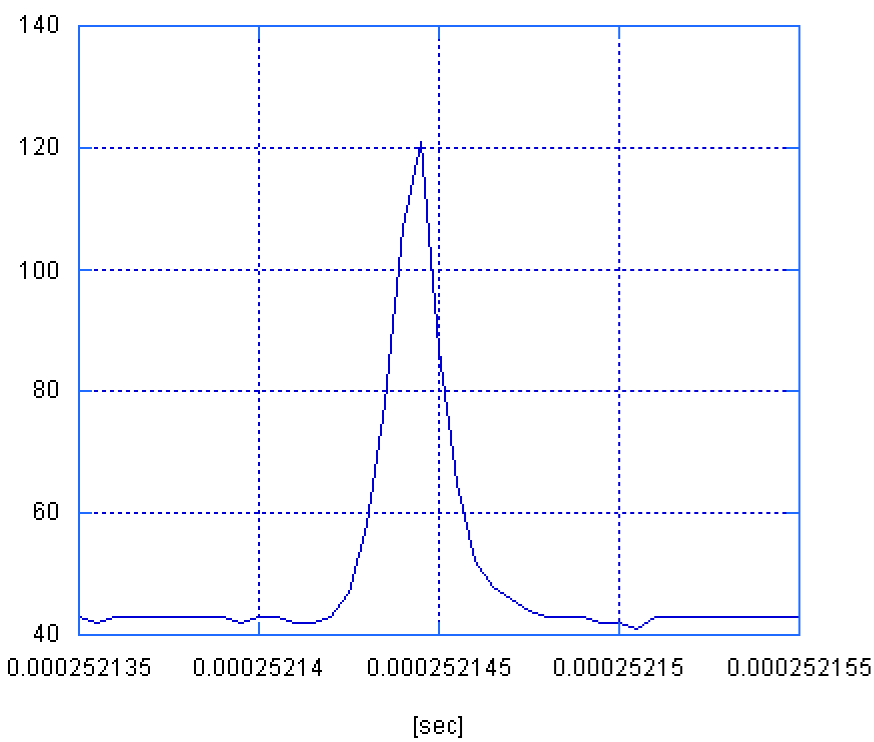


Figure 7. Bunch shape at 120GeV. 5nsec/div.

5. Conclusion

LLRF timing jitter was eliminated and the emittance was measured again. No undesirable emittance blow up has been observed.

Beam has been accelerated to 120GeV with a beam loss of ~2% at the beginning of acceleration.

Reference

[1] Kiyomi Koba (Feb. 03) MI-294